Rebecca Griffin
184-

FIRST LESSONS

ON

NATURAL PHILOSOPHY,

FOR

CHILDREN.

PART SECOND.

By Miss MARY A. SWIFT,

PRINCIPAL OF THE LITCHFIELD FEMALE SEMINARY.

THIRD EDITION.

HARTFORD.

BELKNAP & HAMERSLEY.

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Rebecca Griffith

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THE favorable reception which has been given to the "First Part of Lessons about Natural Philosophy," has encouraged the writer to offer to parents and teachers of primary schools, the "Second Part," hoping that it may prove useful to those for whom it is designed.

LESSON FIRST.

WHAT IS NATURAL PHILOSOPHY?

NATURAL PHILOSOPHY EXPLAINS THE REASONS OF THINGS, AND TELLS US ABOUT THE PROPERTIES OF BODIES.

What are *Bodies?*

Every thing we see is a *body*.

You have learned about the Attraction of Cohesion — is it found in *all* bodies?

It is; but it is stronger in some bodies, than it is in others.

In what bodies is it the strongest?

In *hard* bodies.

Do we call hard bodies by any other name?

We call them *solid* bodies, OR SOLIDS.

Can you mention some solid bodies?

Wood, and stone, and iron, are solid bodies.

Are cork and sponge solid bodies?

They are.

But they are *soft* bodies—are *soft* bodies solids?

They are.

You said *hard* bodies are solids, how then can *soft* bodies be solids?

Every body that is not *fluid* is *solid.*

What bodies are fluids?

Water, milk, and oil are called fluids.

How do you know that cork and sponge and other soft bodies are not *fluids?*

I can make sponge and cork into any shape I please, and they will remain in that shape, but water and other fluids will not.

If I should place a solid and a fluid upon the table, how could you tell which was a *solid?*

The solid body would remain where you put it.

What would the fluid do?

It would flow on the table, or down from it on the floor.

What do you mean by a fluid?

Something that *flows*, and will not keep its place, unless it is confined in a vessel.

Do all fluids flow like water?

Not all; there are some fluids that are different from water or oil.

Then how many kinds of bodies are there?

Two.

What are their names?

Solids and *Fluids*.

Why are some solids *hard*, and other solids *soft?*

Because the attraction of cohesion is stronger in hard bodies than it is in soft bodies.

What do you mean by the Attraction of Cohesion?

The Attraction of Cohesion is the power of sticking together which God has given to little particles of bodies.

What do we call *hard* solid bodies?

We call them *dense* bodies.

What is *density?*

Hardness.

What bodies are *dense?*

Those bodies are dense whose particles are close together.

Mention some dense bodies.

Iron is very dense, and so is wood.

Which has the greatest density, the iron or the wood?

Iron has the greatest density.

Why has iron greater density than wood?

Because its particles are closer together than the particles of wood are.

How do you know they are?

It does not take so much strength to cut wood, as it does to cut iron.

What do we call *soft* solid bodies?

We call them *rare* bodies.

What is *rarity?*

Softness or thinness.

What bodies are rare?

Those bodies are rare, whose particles are not very close to each other.

Mention some rare bodies.

Cork and sponge are rare bodies.

Which has the greatest rarity, cork or sponge?

Sponge is the rarest.

Why is sponge rarer than cork?

Because its particles are not attracted or drawn to each other as closely as the particles of cork are.

How do you know they are not?

Because sponge is more easily separated than cork is.

When you say the fog is very dense, what do you mean?

I mean the fog is very thick, and its particles are so very near each other, that we cannot see through them.

Is steam a solid or a fluid?

Steam is a fluid.

How do you know?

Because it does not keep its place, and it cannot be made into any shape.

Can the *Air* be made into any shape or figure?

It cannot.

Then is the air a solid or a fluid?

The air is a fluid.

Does the air flow to the ground like water?

It does not.

Why does it not if it is a fluid?

It is too light to fall to the ground.

Where is the Air?

It is all around us — it is what we breathe.

Then we can breathe a fluid, can we not?

We can, and our breath itself is a fluid.

But are air and breath such fluids as water?

No; they are a different kind of fluid.

What is the name given to such fluids as water and oil?

They are called *Liquids*, or *running fluids.*

What is the name of such fluids as breath and vapor?

They are called *aeriform* fluids.

What is the meaning of *aeriform?*

Aeriform means *air-form.*

Why are they called aeriform?

Because they are *like air.*

LESSON SECOND.

If you throw an India-rubber ball upon the floor will it lie there?

It will not; it will bound up into the air.

What makes it bound up?

It is full of air; and the air in it makes it bound.

Would it not bound up if it was filled with something besides air?

It would, but not so high as it does when full of air.

Will you tell me how the air can do this?

When I throw down the ball the side that touches the floor is flattened or bent in, and

does not leave as much room for the air inside of it.

What becomes of the air in it then?

The particles of air are pressed together so closely that they do not take up as much room as they did before.

What presses them together so closely?

The striking together of the ball and the floor, when you throw the ball upon the floor.

How long will the air in the ball stay in so small a place?

Not a moment.

What will it do?

It will instantly spring back, and press out the flat side of the ball as round as it was before.

What will the ball do then?

It will bound up from the floor.

What is the springing of the air called?

It is called *Elasticity*.

When we say the air has the power of springing back, what do we mean to say?

We mean to say that the air is *elastic.*

What other bodies are elastic?

Every body that springs back to its first shape, when it has been pressed in or struck, is an elastic body.

Can you mention some bodies that are elastic?

Ivory, wood, and many other hard bodies are elastic.

What bodies are not elastic.

Clay and wax are not elastic?

How can you tell whether a body is elastic?

By striking it against another body.

What will it do if it is elastic?

It will bound back without seeming to be flattened or bent inward.

How will it be if it is not elastic?

It will not bound back again, but will be flattened.

How do you know that the air is elastic?

If the air *in* the ball is elastic, the air *out* of the ball must be elastic too.

When you stretch a piece of India-rubber, what makes it spring back as soon as you let it go?

Its elasticity.

If you pull out the string of a bow, what will happen to the bow?

It will bend.

What if you let go the string?

The bow will straighten as it was before.

Why will it straighten?

Because the wood of which the bow is made is elastic.

Why do you pull the string hard when you fix the arrow to it?

So that the arrow may fly the farther.

What makes the arrow fly off when you let go the string?

The bow is bent when I put on the arrow, and the moment I let go the string, the bow springs back so quickly that it straightens the string with a jerk, and the arrow is sent into the air.

Now can you tell me what it is that makes the arrow fly off from the bow?

It is the *elasticity* of the bow.

You said the air is a fluid—then are fluids *elastic?*

Some fluids are.

What fluids are elastic?

Aeriform fluids are called *elastic* fluids.

LESSON THIRD.

When you say a body is *moving*, what do you mean?

I mean that the body is *changing its place.*

Then what is the meaning of the word *motion?*

Motion means change of place.

When your ball moves along the floor, what *puts* it in motion?

My hand.

When the arrow flew through the air, what put it in motion?

The springing of the bow made it fly off.

Then what puts bodies in motion?

The *power* of the body that strikes them, or draws them, puts them in motion.

What is this power called?

It is called *force.*

What put the arrow in motion?

The *force* of the elasticity of the bow.

How do you know?

If the bow had not been elastic the arrow never would have left the string.

When a body is moving, what makes it stop?

The power or force of something else makes it stop.

What makes an arrow stop moving, after it has been shot into the air?

If it falls to the ground, it is the force of the attraction of gravitation that brings it down.

If it goes into a tree or a board, what force stops it then?

The force of the cohesive attraction of the particles of wood stops it.

[illegible] cohesive attraction stop it?

[illegible] particles of wood so closely to-[illegible] row cannot separate them.

When the wood will not permit the arrow to go through it what do we say the wood does?

We say the wood *resists* the arrow.

Which is it that resists the arrow, the particles of wood, or the cohesive attraction that draws the particles together?

It is the attraction of cohesion.

How do you know?

If the cohesion could be taken from the wood, the arrow would pass through it.

When you throw a ball into the air, will it move all the time as fast as it did when you first threw it?

It will not, but will go slower and slower till it falls.

When the motion of a body becomes slower and slower, what do we call such motion?

We call it *retarded* motion.

What is the meaning of *retarded?*

Anything is retarded that goes slower and slower.

If you were running, how could you *retard* your motion?

By beginning to walk.

If you were walking, and should begin to run, and should continue to run faster and faster, what kind of motion would that be?

It would be *accelerated* motion.

What do you mean by *accelerated* motion?

Quickened motion.

If you were walking, and should not go any faster or any slower, what motion would that be?

It would be *uniform* motion.

What is meant by *uniform* motion?

Motion that is always alike, never slower or faster.

Mention some body that always moves alike?

The minute hand of a watch, and all the wheels in a watch move just as fast at one time as they do at another.

Then what is the motion of a watch?

It is *uniform* motion.

When a ball is falling to the ground, what is its motion?

It is accelerated motion.

Why is it accelerated?

Because the attraction of the earth draws it more and more, the nearer it comes to the earth, and this makes the ball fall faster and faster.

When you throw up a ball what is its motion?

It is retarded motion.

Why is it retarded motion?

Because the attraction of the earth draws it down when my hand sends it up, and this makes the ball go slower and slower, till it finally falls to the ground.

How many kinds of motion have you mentioned?

Three.

What are they called?

Retarded motion, *accelerated* motion, and *uniform* motion.

How does a body move when its motion is retarded?

Slower and slower.

How when its motion is accelerated?

Faster and faster.

How when its motion is uniform?

Neither faster nor slower, but always alike.

When you say a ball *ascends*, what do you mean?

I mean that the ball goes up, or rises.

When a body *descends*, what does it do?

It goes down, or falls.

What kind of motion does a body have when it ascends?

Retarded motion, because it rises slower and slower.

What is the motion of a body when it *descends?*

Accelerated motion, because it falls quicker and quicker.

[illegible] the motion of water when it is fall- [illegible] ct?

[illegible] ted motion.

LESSON FOURTH.

When you throw a ball against the wall, what becomes of the ball?

It will bound back, as if the wall threw it back to me.

What is its motion from the wall back to you called?

It is called *reflected* motion.

What is meant by *reflected* motion?

The motion made by *throwing* back any thing.

What is the meaning of the word *reflect?*

It means to *throw back* again.

Then when I say a body is reflected, what do I mean?

You mean that the body is *thrown back* again.

If I should strike a ball to make it go one way, and you should strike it to make it go another way, what would its motion be called?

It would be called *compound* motion.

Why would it be called *compound* motion?

Because it would be two motions put together.

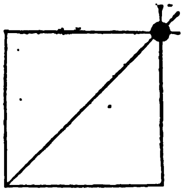
What two motions would it be?

The motion which your hand gave it, and the motion which my hand gave it at the same time.

Which way would the ball move, if we struck it together?

It would not go the way your hand sent it, nor the way my hand sent it, but it would move between those ways.

Here is a diagram which will show you how the ball would move.



When you hold a string that is tied to a ball, and swing the ball round, what is the motion of the ball?

It is *circular* motion.

Why is it called *circular* motion?

Because the ball moves around in a circle.

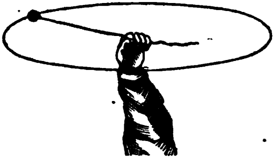
What is the motion of the earth around the Sun called?

It is called *circular* motion.

Why?

Because the Earth moves in a circle around the Sun.

Here is a diagram which shows you what circular motion is.



If you throw your ball forward, will it fall down to the ground in a *straight* line?

No; it will make a curved line, like the diagram.

What, then, is the motion of the ball called?

It is called *curvilinear* motion.

What is the meaning of *curvilinear?*

Curved line.

Then what is *curvilinear* motion?

Motion in a *curved line.*

What makes the ball move in a curved line?

My hand sends it straight forward, and the

of the earth draws it straight down.

Then which way will the ball move ?

It cannot go either way, but goes between.

Then is *curvilinear* motion *compound* motion ?

It is.

Why ?

Because it is the motion made by my hand, and the attraction of gravitation together.

Is *circular* motion *compound* motion also ?

It is.

Why ?

Because it is made by throwing the ball into the air, while, at the same time you keep it from going off by holding the string.

How is the circular motion of the earth compound motion too ?

The *centrifugal force* makes it go from the centre, and the *centripetal* force draws it to the centre.

To what centre ?

The Sun, because the Earth moves round the Sun.

The *power* of the body that strikes them, or draws them, puts them in motion.

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How does the cohesive attraction stop it?

It keeps the particles of wood so closely together that the arrow cannot separate them.

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What is the motion of water when it is falling in a cataract?

It is accelerated motion.

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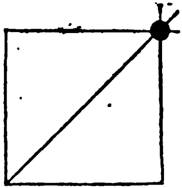

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LESSON SIXTH.

How do children play at *see saw?*

They take a plank of wood, and lay it across a block or a fence, and then one sits on each end, and they swing up and down the *see saw.*

What is the plank sometimes called?

It is called a *lever.*

What is a lever?

A rod or plank that will not bend is a lever.

What is the block that it rests upon called?

It is called a *fulcrum.*

What is a fulcrum?

That which the lever or plank stands upon, when its ends are moving up and down.

If the plank was laid across a fence, when you play *see saw*, what would be its *fulcrum?*

That part of the fence that it lies across.

What are the parts of the lever each side of the fulcrum sometimes called?

They are called *arms* of the lever.

Then if you were playing at *see saw*, where would the arms of the lever be?

I should sit on one *arm* of the lever, and my companion would sit on the other *arm.*

If you are just as heavy as your companion, where must the block, or the fulcrum of the plank be placed?

Exactly in the middle, so that one arm may be just as long as the other.

Then if you sat still upon the plank, would it move up and down?

Each arm would exactly balance the other, and it would stand still.

When do bodies balance each other?

When one is just as heavy as the other.

If your companion was twice as heavy as you are, how must the plank be placed on the fulcrum?

So that the arm on which I sit may be twice as long as hers.

Where would the fulcrum be then?

Near my companion.

What *power* sets the lever in motion up and down?

We are the power; because I strike my feet on the ground so as to send myself up, and that makes my companion go down, and then she does the same and goes up while I go down.

If a stone much heavier than yourself should

be placed on one arm of the lever, how could you raise up the stone?

By putting the fulcrum so near it, that the arm on which the stone lies would be very short, and the other arm very long.

Would you have to use much strength to raise it then?

I should not if the long arm was very heavy.

Why would you not?

Because the long arm would be so heavy that it would almost raise the stone on the other arm of itself.

Then, what is the use of the lever?

It assists us in raising large and heavy bodies.

In raising the stone, what was the power?

My hand.

What the weight?

The stone.

What the fulcrum?

The block upon which the lever rested.

Where was the fulcrum placed?

Between the power and the weight, or between the hand and the stone.

Is a pair of scissors like a lever?

Yes, it is two levers fastened together.

Do both levers move the same way?

No, when one moves up, the other goes down till they meet together.

What is the fulcrum of each lever?

They both have the same fulcrum.

What is it?

Each lies across the other, and they are fastened together in that place by a small rivet or screw that goes through them.

Then what is the true fulcrum of the scissors?

The rivet that fastens the scissors together.

What is the power that moves these levers?

My hand.

What is the weight of each lever?

If I am cutting paper, the paper is the weight.

Will you tell me why the paper is the weight?

Because when I am cutting it, I lift the paper up with the lever which my thumb draws down, and press down the paper with the lever which my fingers draw up.

How will this cut the paper?

The levers are screwed so tight to each other, that when they come together there is no room for the paper between them.

What becomes of the paper then?

One part of the paper remains on one side of the scissors, and the other part is on the other side, and the scissors are between them.

Then what have the scissors done to the paper?

They have *divided* it.

Are the scissors the same kind of lever as the see saw?

They are.

How do you know they are?

Because in them both the power is at one end, the weight at the other, and the fulcrum between.

When a merchant weighs out a pound of sugar, how does he do it?

He takes a pair of scales or balances, like this picture,

and puts a piece of lead that weighs exactly a pound into one of the scales.

Then what does he do with the sugar?

He puts just as much sugar into the other scale as will lift up the weight in the first scale.

How can he tell when he has put in a pound of sugar?

When one scale is just as heavy as the other then the sugar is weighed right.

Are these scales like a lever?

Yes, they are a lever.

Which is the fulcrum?

The place where they are hung up is the fulcrum.

What is the weight?

The sugar is the weight.

What is the power that raises the sugar?

The lead in the other scale.

Then, is not the lever very useful?

It is; it would be very difficult for us to do many things without the lever.

LESSON SEVENTH.

WHEN you open a door, which is the weight that you move?

The door is the weight.

What is the fulcrum?

The hinges are the fulcrum.

What is the power?

My hand.

Is the door such a kind of lever as the see saw?

It is not.

Why is it not?

Because the weight is between the power and the fulcrum.

How is it with the see saw?

The *fulcrum* is between the power and the weight.

Is there any other kind of lever?

There is one more.

What is it?

It is a lever which has the *power* between the weight and the fulcrum.

Have you ever seen such a lever?

Yes; when I have seen a man raising a ladder against the wall.

What was the fulcrum?

The ground on which the bottom of the ladder rests.

What the weight?

The ladder.

What was the power?

The strength of his hands.

Then how many kinds of levers are there?

Three kinds.

What is the first?

One where the fulcrum is between the power and the weight — as the see saw.

What the second?

One where the weight is between the power and the fulcrum — as the door.

What the third?

Where the power is between the fulcrum and the weight — as a man raising a ladder.

What is another way of raising weights besides the lever?

The wheel and axle.

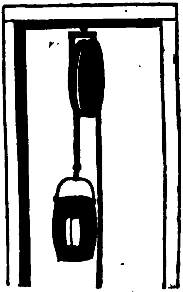
What is the shape of a wheel?

It is round like a hoop with sticks called spokes going from the outside to the centre.

What is the axle of a wheel?

The place where the spokes are fastened in the centre of the wheel.

Here is the picture of a wheel and axle.



What is the use of a wheel and axle?

It is used to raise weights.

Have you ever seen a wheel and axle used in raising a weight?

Some wells have a wheel and axle to raise up the bucket of water out of them.

How is it done?

The rope or chain on which the bucket hangs is fastened to the axle and so when the wheel turns around, the rope winds around the axle, till the bucket comes up.

Can you tell how a wheel and axle is like a lever?

The spokes are the long arms of the lever, and the part of them that goes into the axle are the short arms.

Why will a ball roll down upon the floor if you place it upon a desk?

Because the desk is not level like a table, but inclines downwards.

What may a desk then be called?

An *inclined plane*.

What is a plane?

A smooth surface.

What is an *inclined plane?*

A smooth surface that slopes or inclines downward.

What is the use of an inclined plane?

It is used to raise weights.

How is a weight raised easier by an inclined plane than without it?

If we put one end of a long board upon a wagon, and let the other rest upon the ground,

and roll a barrel up the board into the wagon, we shall find it much easier than it would be to lift it straight up from the ground into the wagon.

Here is a picture of an inclined plane, with a weight rolling up upon it.

LESSON EIGHTH.

WHAT is the shape of the blade of a knife?

It is like two inclined planes put together.

What would the blade of a knife be called in Philosophy?

It would be called a *wedge*.

What is a *wedge?*

It is like two inclined planes put together, so as to have a sharp edge on one side, where they meet.

Of what use is a wedge?

We could not cut or divide anything if there were no wedges.

Mention the names of some wedges?

A knife is a wedge, and so is an axe, and almost all cutting instruments are wedges.

Here is a picture of a wedge.

Have you ever seen a screw?

I have very often.

Where have you seen them?

A pair of scissors is fastened together with a little screw, and hinges and locks are fastened upon doors with screws.

Why are not nails as good as screws to fasten them with?

A nail might be pulled out, but the sharp edge that rises and winds around the screw, keeps it in tight, just where it is fastened.

What is a screw like?

It is much like a round nail with a sharp wedge wound around it.

Here is the picture of the screw.

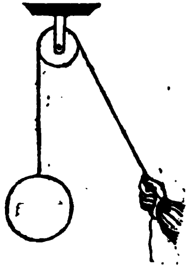
Of what use is the sharp edge or wedge around the screw?

It cuts the wood where it goes in while we are turning it.

What is a *pulley?*

A pulley is a little wheel with its edge hollowed out so as to make a place for a cord to wind around it.

Here is one with a cord upon it.



Of what use is a pulley?

Weights are raised by means of pulleys, and removed to other places.

How do they help people to raise weights?

The weight is fastened to one end of the cord, and a person can raise the weight by pulling down the other end of the cord.

How are buckets of water sometimes raised out of a well?

A rope is put over a large pulley, a good ways above the top of the well, and the bucket

is fastened to one end of it, and a large stone to the other.

How is an empty bucket drawn down into the well?

We pull down that end of the rope on which the bucket hangs, and the stone on the other end rises.

Then, what do you do?

When the bucket has filled with water, we can raise it with a very little strength, because the stone on the other end is so heavy that it almost lifts up the bucket itself.

How many kinds of pulleys are there?

Two; the *fixed* pulley and the *moveable* pulley.

What is a fixed pulley?

A pulley that does *not* turn round like a wheel.

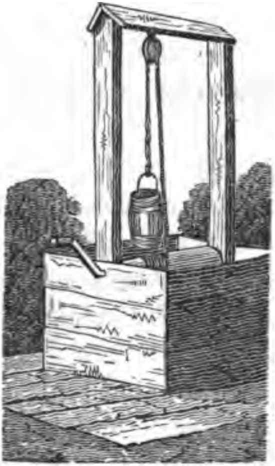
What is a moveable pulley?

A pulley that *does* turn like a wheel.

Which is the most useful?

The moveable pulley.

Picture of a well and bucket raised by a pulley.



LESSON NINTH.

WHAT are the lever, wheel, pulley, inclined plane, wedge, and screw called in Philosophy?

They are called *Mechanic powers.*

What do you mean by mechanic powers?

The power of machines or instruments.

Of what use are the mechanic powers?

They help us to raise and move very large weights, and to divide and cut hard bodies into any shape we please.

Can you mention some useful machines or instruments?

Coffee-mills, clocks and watches, and steam-boats are useful machines.

Of what use are steam-boats?

They carry very heavy loads of goods and people, across the water much faster than vessels can.

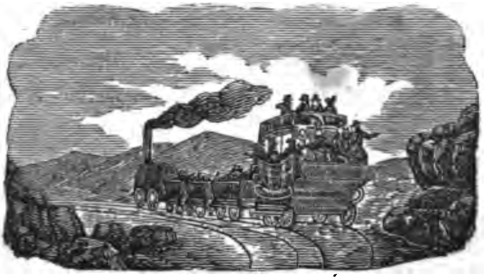
How can they do this ?

By means of the power of the machinery in them.

What keeps the machinery in motion ?

The power of the steam in the boilers.

How can the carriages on rail-roads move on so very rapidly ?



It is by means of the power of the machines in them.

Does steam keep these machines in motion ?

In some carriages it does, but in others, horses keep the machinery in motion.

What is the meaning of machine or machinery?

When several instruments or mechanical powers are put together, we call the whole a machine or machinery.

What did you say kept the machinery of steam-boats in motion?

The steam in the boilers.

What is steam called when it moves machiery?

It is called a *moving power*.

Then what is the moving power of steam-boats?

Steam.

What is the moving power of rail-road cars?

Steam and horses.

What is the moving power of a clock?

Weight or gravitation.

How do you know?

It is gravitation which draws down the

weights that turn the wheels, and keeps the clock going.

In mills and manufactories upon the banks of rivers what is the moving power?

The water.

How do you know?

It is the water running upon the great wheels that keeps them turning, because when the stream is very low, or almost dry the wheels stop turning.

Is water the moving power of all mills?

No; the moving power of some mills is wind.

What are such mills called?

Wind mills.

When animals or men move machines, what do we say the moving power of such machines or instruments is?

Animal strength, or the strength of men and animals, is their moving power.

Who has provided the moving powers of all machines?

The Creator of the world.

What good have they done for man?

They save him from much very hard labor.

How do they do this?

It would take all the strength of a great many men to lift, and carry, and cut a great many heavy and hard bodies, that one man can do alone with a machine.

Can you mention one example?

In cotton factories, where cotton cloth is made, they have machines to card and spin, and weave, so that a very few persons can make hundreds or thousands of yards of cloth in a day from cotton that is brought in that morning.

Can you mention another example?

On rail-roads a little steam engine can draw a great many heavy loaded carriages, thirty miles in one hour.

Who teaches man how to save his labor by contriving these machines?

Our Creator.

How does he teach us?

He made the wood and iron of which machines are made; and the wind and water, and strength that moves them; and the mind in us that thinks, and contrives how to use these things.

Can you describe a machine so curious that it could never have been made without a great deal of thinking and contriving?

A man in England made two clocks, and sold them to some gentlemen, who sent them as a present to the Emperor of China. Each clock was in the shape of a little chariot. A very small *lady* sits gracefully in it. Her right hand is leaning upon the chariot. Under her hand is a curious little *clock*, about as large as a shilling piece. This clock strikes every hour, and will go eight days without being wound up. Upon the lady's finger sits a beautiful little *bird*, adorned with diamonds and rubies. Its tiny wings are spread out ready to fly, and if a diamond button below it is touched, the bird will flutter for some time.

What makes the bird move?

Its little body is full of very small wheels which make it move.

How large is the whole body of the bird?

About the size of a *pea*.

Can you tell any thing more about the clock chariot?

The lady holds in her left hand a gold tube, no larger than a large pin. On the top of this tube is a small round box. Around this box is a ring made with gold and diamonds, not larger than a sixpence. This ring goes round and round the box, three hours at a time without stopping.

Can you tell what is over the lady's head?

There are two small *umbrellas*, standing upon a pillar no larger than a quill. Under the largest umbrella is a little *bell* which strikes every hour. At the lady's feet is a golden *dog*, and before it are two little *birds* fastened upon springs. Their wings and feathers are very brilliant with precious stones, and they seem to be flying away with the chariot.

How can the chariot move along?

By means of springs and wheels that are out of sight. If they are touched they can make the chariot go straight forward, or in a circle, or in any way that you wish.

What is behind the chariot?

A little golden *boy* taking hold of it and seeming to push it along. Above the umbrella are *flowers* and *ornaments* of precious stones; and at the top of the whole stands a little *flying dragon*, made of the same brilliant stones.

What good lesson should we learn from this story?

That the man who made these wonderful *clocks* had great *skill;* and that God, who made the man, and gave him so much skill, must be more skilful than all the men in the world — *more skilful than we can think.*

LESSON TENTH.

If you let go of your book what will it do?

It will fall to the ground.

What *power* draws it to the ground?

The power of *gravitation.*

Does this power show itself every where, when bodies have nothing to hold them up?

It does.

What kind of a power do we call the power of gravitation?

A *natural* power.

What do you mean by *natural* power?

A power that God has given to bodies, and that man cannot make.

Is there any other power besides natural power?

Yes; there are *mechanical* powers.

What kind of power is mechanical power?

The powers that mechanics have — such as pulleys, levers, and wheels.

If a stream of water runs very swiftly under a wheel that is partly in it, what will the wheel do?

It will turn over continually.

What will make the wheel turn?

The water that runs along under it.

Does *man* give this power to running water?

He does not; God gives it.

Then is the power of running water a *natural* or a *mechanical* power?

It is a *natural* power.

When the wind blows against the vanes of a windmill wheel, what does the wheel do?

It turns round very fast.

What makes it turn?

The power of the wind.

What is wind?

Wind is *moving air.*

Is the power of moving air made by man?

It is not; God made it.

Then is moving air a *natural* or a *mechanical* power?

It is a *natural* power.

When you throw a ball, what becomes of it?

It moves on in the direction in which I threw it.

What makes the ball move on?

The power of my arm.

Do you make this power?

I do not; God made it.

What do you call this power that God has given to men and animals?

We call it *animal strength.*

Then is animal strength a *natural* or a *mechanical* power?

It is a *natural* power.

What other name is given to power?

Power is sometimes called *force.*

Then how many natural forces are there?

Four.

What are they?

Gravitation, or the *weight of solid bodies* — the force of *flowing water* — the force of *moving air*, and *animal strength*.

Could men make machines without these *natural* forces?

They could not.

Which of the natural forces assists men in all machines?

Gravitation.

Which *natural* force helps men in their mills and factories?

The force of flowing water.

Can there be *mechanical* power without *natural* power?

There cannot.

How do you know there cannot?

Because all machines have weight, or something that draws them down to the earth, and

many have the power of running water to help them to move.

Can there be *natural* power without *mechanical* power?

There can.

How do you know?

There is no mechanical power to bring an apple down to the ground; gravitation can do it alone; and running water will carry a boat along, and sometimes tear up trees, and roll rocks over a cataract without any help.

Do all animals have the same strength?

No; some are very weak, like the lamb, and others are strong, like the lion.

Are all men equally strong?

No; some men have ten times more strength than others.

Can you mention the name of a very strong man?

Sampson, whose story is in the Bible, was the strongest man that ever lived.

What wonderful thing did he do by his strength?

He was carried by his enemies, the Philistines, into the house of their god, so that the people might make sport of him because his eyes were put out. The house was full of men and women. It was so very large that there were upon the roof about *three thousand* men and women that beheld, while Sampson made sport.

"And Sampson called unto the Lord, and said, O Lord God, strengthen me, I pray thee only this once, O God, that I may be at once avenged of the Philistines for my two eyes.

"And Sampson took hold of the two middle pillars upon which the house stood, and on which it was borne up, of one with his right hand, and of the other with his left.

"And Sampson said, let me die with the Philistines. And he bowed himself with all his might, and the house fell upon all the people that were in it.

Do common men ever show very great strength?

They often do.

Can you mention any such men?

The men who carry travellers up the mountains in Peru, show very great strength.

How do they show it?

They will carry loads that weigh two hundred pounds during eight or nine hours a day, up the mountains.

What are these men called?

Carueros, or carriers.

Which has the greatest weight, a cannon ball or a bullet?

A cannon ball.

If you could throw a cannon ball against a thin board, would it go through the board?

It would not.

If a bullet should be shot out of a gun, would it go through the board?

It would.

Why would the bullet go through when the cannon ball which is much heavier, would not?

Because the bullet goes so much faster than the ball.

What is swift motion called?

Velocity.

Then why will the bullet go through the board, when the ball will not?

Because the weight and *velocity* of the bullet together, is greater than the weight and velocity of the ball when put together.

When weight and velocity are put together what is the whole called?

The *momentum* of the body.

Which momentum is greatest, then, that of a cannon ball thrown by the hand, or that of a bullet fired from a gun?

That of the bullet.

How could you increase the momentum of the cannon ball?

By firing it from a cannon.

LESSON ELEVENTH.

WHICH would a sled slide down most easily, a hill of sand, or a hill of ice?

The hill of ice?

Why would it slide most easily over that?

Because sand is rougher than ice.

Then does the roughness of the sand hinder the sled from sliding down?

It does.

What is the name that philosophers give to this roughness when bodies are rubbing against each other?

They call it *friction*.

Which can you turn most easily, a rusty lock, or a bright one?

The bright one.

Then which lock has most *friction?*

The rusty one.

Why will a person slip down upon ice, and not upon stone or earth?

Because there is more friction when his feet rub against the stone than when they rub against the ice.

How could the rusty lock be made to turn as easily as a bright one?

By oiling it.

Why would oiling it make it turn easily?

It would take away some of the friction.

How would it take away the friction?

By making the iron smooth.

Can you mention another example of friction?

I have heard carriage wheels creak, because they wanted greasing.

Why do people grease carriage wheels?

To make them smooth and turn easily.

Why will the grease make them turn easily.

It destroys some of the *friction* made by the rust and rough iron.

Why do drivers of carriages, when going down steep mountains, fasten one of the wheels, so that it cannot turn?

To increase the friction of the wheel, and prevent the carriage from going down so fast.

What does *increasing the friction* mean?

Making it more difficult for the wheels to go down hill.

How many kinds of friction are there?

Two.

What are they called?

The *dragging* and the *rolling* friction.

Can you mention an example of dragging friction?

The chained wheel *dragged* down the hill.

What is an example of *rolling* friction?

Wheels when they are turning or rolling.

When the walks are covered with ice why is it difficult to walk upon them without slipping?

Because there is not friction enough.

What would happen to us if there was no friction?

We could not walk a step before we should begin to slip along very fast, and could not stop ourselves.

How do people increase the friction when the walks are covered with ice?

They throw sand or ashes or something rough upon them?

Could you hold any thing in your hand if there was no friction?

Not without difficulty.

Why?

Because it would slip through so easily.

Then is not friction very useful?

It is; for I could not hold my knife and fork or book, very easily, without friction.

How do people travel from Mount Cenis, in Europe, to the town of Laneburg?

On the top of the steep snowy precipice, the traveller gets into a sledge and slides down so swiftly that he goes three miles in seven or eight minutes, and his breath is almost taken away from him, by the motion.

What makes him go down so fast?

The ice is so smooth that there is scarcely any friction when the sledge glides over it.

Why is it much easier to travel and to carry heavy loads upon snow, than upon the ground?

Because the snow is so very smooth, that the friction is almost destroyed, and the runners slide along more easily than wheels roll along the ground.

Why would not wheels go as well upon snow and ice, as the runners of sleds?

Because the wheels would sometimes roll and sometimes slide along, and the horse would find it difficult to draw the carriage steadily and

LESSON TWELFTH.

Do you recollect what you learned about springs?

I learned that they were made by the water under ground, bursting out at the top, when it could go no farther under ground.

When a spring bursts out a little while, and then stops, and then goes on again, and continues stopping and going on, what is it called?

It is called an *intermitting* spring.

What is the meaning of intermitting?

Any thing that sometimes goes and sometimes stops, is called intermitting.

Can you tell what is the cause of intermitting springs?

They stop or *intermit* at times, because there is not enough water under the ground to keep them running the whole time.

Why do some of these springs run in *dry* weather, and stop in *wet* weather?

Because when it rains it takes sometime for the water to run down into the earth where the basin of clay is, and by the time it gets there the rain is over, and it is dry weather.

Why does it stop running in wet weather?

Because all the water in the basin under ground, will run out before it rains again, and so while it rains, the spring must stop running till the water has time to run down through the earth and fill the clay basin; and by that time it will be dry weather again.

Why are not *all* springs *intermitting* springs?

Because some basins are so large that they are never empty, from one rain to another.

Does the rain make all springs?

It does not.

W[illegible] [illegible]es rain causes springs?

The springs which are near those mountains that are always covered with snow, are made by the melted snow.

What would become of the water that flows from the springs, if there should be mountains and hills all around them?

They would fill up the valley between the hills, and this would form a *Lake*.

Where would the water go when the valley was filled up with it?

It would flow out of the first opening it could find, and become a river.

Are there any such lakes and rivers in the world?

Yes, many.

Will you mention one.

Lake Geneva, in Switzerland, is formed so.

You may tell what you know about it.

The river Rhone ran down from the mountains till it came to this valley made by the high hills all around it, and there it stayed till it

had filled it and found an opening, and then the river ran on to the ocean.

What is this valley full of water called now?

Lake Geneva, and it is a beautiful lake, almost at the top of the mountains.

Are all lakes found in this way?

The most of the lakes in the world are.

Then what is a lake?

A valley full of water.

Are lakes always full of water?

They are not always; some are *dry*, part of the year.

Can you mention any?

Lake Merow, is such a lake, in Palestine.

What can you say of Lake Merow?

It is a small lake made by the river Jordan. When the snows on Mount Lebanon melt, and run down in the Jordan, this lake is full and is several miles long; but when the hot weather comes on, it dries up.

Do you know of any other such lake?

In Germany there is one called Cirenitz lake.

Will you describe it?

It is four or five miles in length, and about two miles wide. All around it are wooded mountains, in which live deer, wild boars, and hares. A part of the year the people come here in boats to fish, and the other part they may sow and reap grain, and hunt these animals.

Can you tell about a very curious way of fishing these people have?

When the water goes out of the lake, it runs through eighteen holes at the bottom, carrying the fish with it. This makes so many little whirlpools. When the water has all run through, the peasants go down with lights into one of these cavities. This cavity or hole is several feet under the bottom of the lake, in a solid rock. Here the water runs down again, through small holes as through a sieve, and the poor fishes are left behind for the peasants to catch.

Can you mention any more remarkable accounts about this lake?

When it begins to rain hard, three of these cavities spout up water to the height of twelve or eighteen feet. If the rain continues, and it thunders, the water will bubble out of the holes through which it had run, and the whole lake will fill again in a single day. Sometimes not only fish, but *live ducks*, with grass and fish in their stomachs, will come up with the water out of the holes.

LESSON THIRTEENTH.

WHAT very remarkable lake do you read of in the Bible?

Lake Asphaltites, or as it was often called the *Dead sea*.

What do you know about this lake?

It is supposed to have been caused by the destruction of Sodom and Gomorrah.

How does it differ from other lakes?

The water in it tastes salt, and different from sea water.

What is found mixed with the water to give it such a taste?

Salt and Magnesia and Bitumen.

What is bitumen?

It is some like tar, and will burn like oil when set on fire.

Do you know of any other wonderful lake in Asia?

In the northern part of Asia, is a large lake which throws up a liquid which the people collect and put in their lamps to burn.

Are there any springs in the world like these lakes?

In Italy there are *oily* springs.

What can you say of them?

Their surfaces are covered with oil, that smells very fragrant when it is burning, and is of different colors.

How much oil is collected from some of these springs?

From one spring near the Appenine mountains, which comes out of a rock, people can collect *twelve pounds* in one week.

What is the name of this rock oil?

Petroleum.

What is the meaning of the word Petroleum?

Petre means *rock* and *oleum* means *oil*.

Why is it called rock oil?

Because it comes up from rocks.

Is this oil ever found upon the sea?

It is found in the sea near mount Vesuvius.

How does it first show itself on the water?

While it is rising to the top of the sea, the water seems to be covered with bubbles.

How do people gather it?

They skim it off as they sit in their boats, and then put it into pots and jars.

Does this petroleum rise to the top of the water all the time?

It rises only in warm weather.

What different colors has the oil?

Some is white, some yellow, some red, and some black.

Which oil is the best?

The white clear oil.

Which is poorest?

The black, because it is not pure.

Are there any springs of petroleum in this country?

There is one in Kentucky.

Do you know of any other kinds of springs besides the oily springs, and springs of good water?

In Iceland there are *boiling* springs.

Why are they called *boiling* springs?

Because they are as hot as boiling water.

Are they of any use to the people of Iceland?

The Icelanders boil and cook their food with them.

What other springs have you heard of?

Warm springs.

Why are they called *warm* springs?

Because the water that comes up from them is always *warm*.

Where are any warm springs?

In Virginia.

What very useful springs are found in the United States?

Mineral springs.

Why are they called *mineral* springs?

Because they have sulphur, and iron, and salt, and other minerals in them.

Have they any different name?

They are often called *medicinal* springs.

Why are they called *medicinal* springs?

Because they cure diseases, as medicine does.

Can you mention the names of some of these springs?

There are Ballston and Saratoga springs, in the state of New York, and Yellow springs in Ohio, and many others in different states.

What curious springs are sometimes found in the sea, near the shore?

Springs of *fresh* water.

How can it be got, without mixing it with the salt sea water?

A bottle corked tight, can be let down

directly over the spring, and when it is low enough, the cork can be drawn out, and the fresh water will instantly fill the bottle, which can then be drawn up.

What are *hot* springs?

Those whose water is aways *hot.*

What are *cold* springs?

Those springs which are very cold in warm and cold weather.

What becomes of the water that rises from springs?

It runs into streams and rivers.

Where do the rivers carry their water?

Into lakes and seas, and into the ocean.

Does the water of springs always run into rivers or lakes?

Not always; sometimes it disappears before it can get to a river.

What becomes of it?

Sometimes it is turned to vapor by the heat [illegible] sun.

What do we say of water when it is turning into vapor?

We say it is *evaporating*.

What would become of the earth if water did not evaporate?

The earth would be so full of water, that there would be no solid ground.

Was the earth ever so full of water?

It was at the Creation.

Does the water of springs ever disappear in any other way?

It sometimes sinks into the earth, as the water of some lakes does.

Can you tell me of one such spring?

In Palestinĕ, near mount Lebanon, there is a spring called *Phiala*, because it looks like the mouth of a vial; and the water from this spring goes down into the ground.

Has any one ever found out what becomes of it under ground?

In the life time of Herod the Great, the spring and a stream that came out of the

ground thirteen miles from this spring were examined.

How did people examine them?

They knew that wood always floats upon the top of water; and they threw some wood into the spring, and it went down into the ground.

Was it ever seen again?

The people who were watching the stream that came out of the ground thirteen miles south of the spring, after looking sometime, saw those very pieces of wood come out in it.

What did this prove?

That this stream ran under ground thirteen miles.

What is the name of this stream?

It is the river *Jordan* that we read so much about in the Bible.

What do you learn from this river, about streams that disappear?

That such streams do run into rivers and lakes when we think they evaporate.

What bad effect would happen if the water was not carried off out of a lake?

The water would become very bad, and fill the air with a dreadful vapor, which would make people sick.

LESSON FOURTEENTH.

When the wind passes over stagnant lakes or pools, and carries the bad air into other places, what are such winds called?

Pestilential winds.

Why are they called pestilential?

Because they make people who breathe them, have a dreadful disease, that causes them to die very soon.

What are such dreadful diseases called?

Pestilence or Plague.

Are there any other kinds of pestilential winds?

The samiel is a pestilential wind.

Where does it come from?

The desert of Arabia.

What makes it so dreadful?

It is very hot, and will destroy life immediately, if it is not guarded against.

Do travellers know when the samiel is coming?

They do.

How do they know?

They see something at a distance that looks like a cloud of dust rising from the ground.

What do they do then?

They lie down, and put their faces close to the ground, until the wind has passed over them.

Is it the heat alone which destroys life?

It is supposed that the wind is poisonous as well as hot.

What remarkable winds blow in Egypt?

They have, besides the simoon, *periodical* winds.

Why are they called periodical?

Because they blow only at certain seasons or periods of the year?

What do you know of these winds ?

They begin in the month of June by blowing from the northwest.

How long do they blow from this direction ?

Till September, and then they change and blow from the north and east till February.

What happens to the waters of the Mediterranean sea during this time ?

The vapors that rise from the sea are cooled into mist and sometimes into rain.

Which way is the Mediterranean sea from Egypt ?

North-west and north.

At the end of February, where do these winds blow from ?

The south, and afterwards from the south-west and south-east.

In May which way does the wind change ?

To the east.

[illegible] June how does the air move ?

The air high above the ground, moves to the south, and the air nearer the ground, moves to the north.

What becomes of the vapor that rises from the sea?

The higher current of air carries this vapor across Egypt down to Abyssinia.

When the vapor reaches this country, what becomes of it?

It changes into rain and falls in torrents to the ground.

Where does the water then go?

Some of it runs into the river Nile and makes the river overflow its banks.

What good does this river do?

It passes through Egypt where it never rains, and when it overflows its banks, the whole country is watered by it.

While the upper current of air is carrying the vapors from the sea to the south, what is done by the lower current of air?

It takes the vapors that rise in Abyssinia

after the rain, and carries them to the north, where the river Euphrates rises.

What happens to this river then?

When the vapor falls in rain, this river rises as the river Nile does.

How many times in a year do these rivers rise in this manner?

Once only.

What is this overflowing of the rivers called?

Inundations.

What would happen if there were no such inundations?

The land of Egypt would be like a desert, and nothing could grow there.

Why would it be so dry and barren?

Because they have no rain, and all their water comes from this river.

How does this show the *kindness* of God?

It shows that He will provide for the wants of man, in all countries where men live.

How does it show His *power?*

We see from this, that He is able to bring

water where it is needed, even when it does not fall from the clouds. "He causeth the wind to blow and the waters flow."

When a whirlwind passes over the ocean, how does it affect the waters?

It whirls them up into a column, high in the air, and then they burst and fall down.

What if the whirlwind passes over a desert of sand?

The sand will rise as the water does.

What causes a whirlwind?

When wind rises suddenly from almost every point, it is very rapid, and makes sand and dust, and water whirl up and down and around in different directions.

When they pass over land what are they called?

Whirlwinds.

What are they called when they pass over water?

Water-spouts.

How do we know that water-spouts and whirlwinds are caused by the same thing?

They both whirl around, and move forward at the same time, both rise after great heats, and both are frequent in hot countries.

What is the strongest proof that they are the same thing?

A water-spout has been known to move from sea to land, and when it had got to the land its motion was like a whirlwind.

Are whirlwinds ever mentioned in the Bible?

The propet Nahum says, "The Lord hath his way in the whirlwind and in the storm, and the clouds are the dust of his feet."

LESSON FIFTEENTH.

Why does smoke rise from the fire and go up through the chimney?

Because the air in the fire place when heated, rises up and carries the smoke, which is also light, with it.

When the smoke goes out of the chimney, why does it not fall to the ground?

Because it is lighter than the air below it, and cannot sink.

What is this like?

Like oil upon water.

Why does not the oil sink below the water?

Because the water is heavier than oil.

If you should put the oil in the basin first, and then pour water upon it, would the oil remain at the bottom?

It would not, but would rise through the water, and lie upon the top of it.

Why would it?

Because the water is so much heavier, that it sinks down, and crowds the oil upwards.

Why will not the smoke spread around the chimney, instead of rising higher?

Because the air above it is heavier, and crowds the light smoke upwards, as the water did the oil.

How high will the smoke ascend?

Till it comes to air that is no heavier than itself.

How long will it remain there?

Till the wind carries it away.

What makes soap-water bubbles rise in the air?

The light air that is in them.

If you could fill a thin bag with very light

air, and throw it into the air as you do soap-bubbles, what would it do?

The bag would rise.

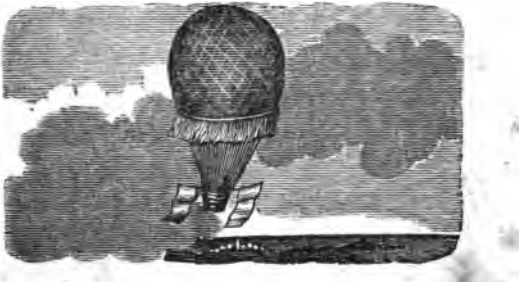
How high would it rise?

Till it came to air of its own weight.

If you should fasten a bit of wood to it, would the bag carry up the wood with it?

It would, if the wood did not make the bag heavier than the air around it.

How are *balloons* made?



A light bag of thin silk, somewhat like a large bubble, is filled with a kind of air lighter than the common air.

How is this air kept from coming out of the bag?

The bag is lined with a varnish, made of India-rubber and spirits of turpentine, so that it is *air tight*.

How can a person go up in such balloons?

A little *car* is fastened to the bag, which can carry one or two persons in it.

How can a balloon carry a loaded car up into the air?

The air in the bag is so very light, that it will go up, and when the car, with one or two people is fastened to it, the whole together are so much lighter than the air around them that they can no more stay down to the earth than smoke can.

Do accidents ever happen to those who ascend in balloons?

Very often.

How?

When the balloon comes down, it sometimes falls into the sea, and the people in it are in-

jured or drowned, and sometimes it strikes a tree suddenly, or is dragged violently along the ground, and the persons in it get hurt.

How can a balloon descend?

By letting out some the light air from the bag.

How will this make the bag descend?

There will be less light air in the bag to keep up the car, and so the balloon will be heavy and descend.

What is a *parachute?*

It looks like a very large umbrella open.

Of what use is a parachute?

If a balloon bag bursts, or a car upsets, and the man in it has a parachute, he can hold upon the handle of it, and keep himself from falling quickly to the ground or sea.

How will the parachute hold him up?

While it is spread out, the air that it covers will support it so much that it comes down gently.

How can you make a little parachute?

By fastening strings to the four corners of a sheet of paper, then bring the four strings together in the middle, and fasten a light piece of wood to them.

Then what must you do?

Carry it to a high place and let it fall.

How will it fall?

Very slowly indeed.

If you should have an open umbrella in your hand while falling or jumping from a high place would you fall heavily to the ground?

I should not.

Why?

The air beneath the umbrella would support it, and the umbrella would almost hold me up from the ground.

How do birds keep from falling, when they are up in the sky?

They spread out their wings, and the air supports them.

Is this the only reason why the air supports them?

No; their bodies contain a great deal of air.

How can they remain in the same place in the air, without descending at all?

They strike the air beneath them with their wings, a very little, and then the air *re-acts* or *strikes back again* a very little and thus they keep their places.

How do they rise in the air?

They strike harder against the air, and the air re-acts just as much and sends them up higher.

How do they descend?

By partly shutting their wings, and letting themselves descend by their own weight.

How do they know exactly what to do when they wish to rise or descend, or stand still?

God, who made them, has taught them, and they never make a mistake, or forget how to do it.

LESSON SIXTEENTH.

How are fishes able to keep themselves from sinking in water?

They have fins that spread out like the wings of a bird, and the water under them supports them, as the air supports the wings of a bird.

But you said that the body of a bird had a great deal of air in it, is it so with fish?

Fishes have bladders of air in their bodies, that make them lighter.

How can they sink down into water when they wish?

God has given them the power of letting out the air from the bladder.

How can they rise again?

God has given them the power of filling these bladders with air again whenever they choose.

How do fishes differ from birds?

Their fins are not so large for them as the wings of birds are for them.

Why are they not made as large?

Because water is heavier than air and supports fish better, so that fishes need no larger fins that God has given them.

How do people imitate fishes when they wish to go into the water?

They take bladders filled with air and fasten them around their bodies under their arms, and the air keeps them from sinking.

Do they ever use any other light body instead of blown bladders?

Cork is so light that it will not sink in water and people use it in the same way as they do bladders.

What are *swimming-girdles, air-jackets* and *life-preserving belts?*

They are India-rubber bags, filled with air and tied around the body, instead of corks or bladders.

What is the danger of using these bags and bladders?

If they should slip down to the hips, the heaviest part of the body would be above them, and the body would instantly turn, so that the head would be downwards and the feet up, and the person would soon drown.

What are *life-boats?*

Boats that contain tight cells along their sides full of air.

Why are they called *life*-boats?

Because they take people from a sinking ship and thus save them from a watery grave.

If you should fall into the water, what must you do first, to keep from drowning?

I must turn upon my back, and keep my

hands down, with the inside of them spread towards the bottom.

How must you place your feet?

I must let them sink lower than my body.

Then what parts of your body will be above the water?

Only the face and a part of the chest.

What must you do then?

I must try to breathe so as to take more air into my body.

When you throw out the air as you breathe will not your body sink?

It will, a little, for an instant.

What effort may you make, to keep from sinking?

I must not make *any*, except to keep my face out, so that I can breathe.

What must you be careful *not* to do?

Not to *scream* or *struggle*.

When may you call for help?

When I am a little over my fright.

Who are the most likely to sink, fleshy people, or those who are not fleshy?

Those who are not fleshy.

Why?

Because the fat part of their bodies, is so much lighter than water.

What amusing account can you give of Marco Paulo?

Marco Paulo was a priest, who lived in the city of Naples, seventy years ago. His bones were very small, and he was very fat. His body, also, would contain a great quantity of air. These things made him so light, that he would swim on the sea like a duck. When he stood up in deep water, the water would not rise higher than his stomach. It is said, that when two men dived into the sea to drag him down with them, the moment they let him go, his body would rise instantly to the surface.

How can heavy bodies, like blocks of mar-

ble, be raised, when they have fallen into a harbor or river?

By fastening casks of air to them with ropes when the water is low.

Why should the water be *low?*

Because the distance between the marble at the bottom, and the casks at the top of the water would be the shortest.

How could it be raised then?

When the water rises, it will bear up the casks with it, and they will carry the marble so that it can be taken into a boat.

Why would not the boat sink after the heavy stone was placed in it?

One reason is because the wood of boats is so light, and they spread out over a large space on the water.

LESSON SEVENTEENTH.

If you should take a small glass tube, open at both ends, and put one end in water, what change would you see in the tube?

I should see the water rise up into the tube.

What makes it rise?

The sides of the tube draw up the water in it.

What kind of *attraction* is this called?

Capillary attraction.

What is the meaning of *capillary?*

Hair-like.

Why is this attraction called *capillary* attraction?

Because the bore through a tube is almost as small as those through a hair.

In what tubes will water rise highest?

In those that have the smallest bores through them.

If you take two pieces of flat glass, and put the two lower edges together, and leave the upper ones a little apart, and put the lower edges in water, what will happen?

The water will rise up between them.

What attracts the water?

The inner sides of the glass.

What kind of attraction is this?

Capillary attraction.

If you dip one end of a piece of sponge into water, why will the water rise above that part that was dipped in?

Capillary attraction makes it rise.

What are the capillary tubes of sponge?

The little holes that we see in it. Sponge is full of large and small capillary tubes.

What makes sponge so useful?

It will hold a quantity of water, and will drink up water, that is spilled.

When such a substance as sponge drinks up a liquid, what do we say it does?

We say it *absorbs* the liquid.

Then what does sponge do to water when put into it?

It *absorbs* the water.

Why will cotton and linen cloth absorb water?

Because the cotton and linen threads of which cloth is made are full of pores, or very fine capillary tubes which attract the water.

If you take a bowl of water, and place it in the sun, and lay one end of a towel in it, what will happen?

After some time, the towel will be perfectly wet, and the bowl will be empty.

Where will the water be that was in the bowl?

In the towel.

How can it go from the bowl to the towel?

The tubes in the linen draw the water out of the bowl.

Of what use are wicks in lamps?

They are a great number of capillary tubes which draw up the oil from the lamp.

Why must not the wick be smaller than the lamp tube?

Because there would not then be tubes enough to bring up the oil.

Why must not the wick be so large as to be crowded tight in the tube?

If the wick was crowded very tightly, the capillary tubes in it would be closed so that the oil could not rise through them.

What happens when you dip one end of a lump of sugar into water or tea?

The liquid will rise and fill the whole lump.

What makes it rise?

The capillary tubes in the sugar.

How are large rocks sometimes split in Germany?

Holes are bored in a straight line at certain

distances from each other, and wooden wedges driven into them.

What is done after this?

Water is poured upon these wedges, and the pores or capillary tubes in them fill with water.

What follows?

The wedges begin to swell, and as they pour water upon them they swell larger and larger till they burst the rock.

Of what use is blotting paper?

It absorbs the ink upon which it is laid.

When sugar or any other substance is dissolved in a liquid what becomes of it?

It is divided into such very small particles that we cannot see them.

How do you know that the sugar is in the water if you cannot see it?

Because the water is sweet after the sugar is put in, and it was not sweet before.

Does the water rise higher in the tumbler after the sugar is dissolved than it did before?

It does not.

What does this prove?

That there are exceedingly small spaces between the particles of water, and the particles of sugar fill up these spaces, so that the water does not rise to make room for the sugar.

What will happen when these spaces are full, if you put in more sugar?

The sugar will sink, and the water will rise in the tumbler.

When water has dissolved as much sugar as it can, what do we say of it?

We say the water is *saturated* with sugar.

If you should fill a tumbler full of marbles could you pour sand in it without taking out the marbles?

I could.

Where would the sand go?

Into the spaces between the marbles.

What is supposed to be the shape of the particles of water?

Round.

Then, when you put sugar into water, what is it like?

Like pouring sand into a tumbler full of marbles.

How large are the particles of water?

Very small indeed.

When chalk powder is put in water will it dissolve?

It will not, but will only mix with it.

How do you know it is not dissolved?

I can see it in the water, and the water instead of looking clear, is thick and white.

What is the difference between *mixing* a solid in water, and *dissolving* it?

When a solid is dissolved it cannot be seen, neither does the water rise in the tumbler.

How is it when mixed?

It colors the water like itself, and makes the water rise in the tumbler.

What are bodies called which can be dissolved?

Soluble bodies, or bodies that can be dissolved.

What are those called which cannot be dissolved?

Insoluble bodies.

LESSON EIGHTEENTH.

WHAT instrument shows the effect of water pressure?

A *Hydrostatic Bellows.*

If you wished to make a *Hydrostatic Bellows,*

what would be the first thing you would do?

I should get two round pieces of board, and fasten them together with leather, so that they would rise and fall together like common bellows.

What would you do next?

I would take a long tube, and fasten it to one side of the bellows, so that the lower end of the tube would open into the bellows.

How would you make the tube stand erect, after it was fixed to the bellows?

By bending it up from the bottom.

What shape must the top of the tube be?

Like a tunnel.

If a man should stand upon the bellows and pour water into the tube, what would follow?

The upper side of the bellows would begin to rise to make room for the water, and raise the man standing on it, higher and higher till the bellows is full.

What supports the man?

The water in the bellows.

How can water run into the bellows, while a heavy man is standing upon it?

The water along the tube presses the water at the bottom of it into the bellows, because its own downward pressure is greater than that of the man.

Then what kind of pressure, does the downward pressure of water make?

Sideways, or *lateral* pressure.

What is the meaning of *lateral?*

Sideways.

Then when the downward pressure of the water in the tube, presses that in the bottom sideways into the bellows, what other pressure follows?

Upward pressure.

What causes the upward pressure of the water?

The lateral or sideways pressure.

How does it?

When there is no more room in the bellows for the water to press sideways, it must press upward, if the water is continually running in, because it can go no other way.

How could you let the water out of your bellows?

By making a hole at the bottom of the tube.

How can you show the pressure of *air* with the same instrument?

Two men may stand on it, and one of them may blow hard into the tube, instead of pouring in water, and they will both be lifted up.

How can they keep the air in the tube and bellows from coming out?

By putting the finger tightly down upon the top of the tube.

If you fill a vial almost full of water and cork it, and then turn it up and down what will you see moving up and down along the side of the vial?

A bubble of air.

If you lay it on an inclined plane where will the bubble be?

Near one end of the vial.

Where will it be if you lay it on a level table?

Exactly in the middle of the vial.

How can you tell whether a table is level, or inclined?

By laying the vial on it, and looking at the bubble, to see if it is in the middle or near one end.

What useful instrument is made in the same way?

A *spirit level.*

Can you tell how a spirit level is made?

A glass tube, like a vial, is filled almost full of colored spirit, and then closed and laid into a wooden case to keep it from being broken.

How is it used?

When people make roads and canals, they use these spirit levels, to find whether the ground is level or uneven.

What are canals?

They are large, long ditches, filled with water, that go from one town to another.

Why are canals made?

Because there are no rivers in just these places where men want them, and so they make rivers for themselves, for boats to sail upon.

Where do they get the water to fill their canals?

From the rivers near them.

What is done when a canal must go across a river?

They make tight stone bridges, which carry the water in the canal safely over the river.

What are such bridges called?

Aqueducts.

What is the meaning of aqueduct?

Aque means *water*, and *duct* means *leader*.

Then what do you mean by *aqueduct?*

A *water leader.*

Why is it called a water leader?

Because it leads the water of canals across rivers.

LESSON NINETEENTH.

If I should take a glass tube, open at both ends, and put it into a bowl of water, and then press down the water around the tube what would it do?

The water would rise up into the tube.

What would make it rise into the tube?

Your hands would press down the water around the tube, and the water could not help rising in the tube.

What is mercury?

It is a liquid metal that looks like melted silver.

What is mercury sometimes called?

Quicksilver, or liquid silver.

If I should put quicksilver, or mercury into the bowl instead of the water, and then press it down, would it rise in the tube?

It would; but not as high as the water rose unless you pressed upon it more than you did upon the water.

Why would it not?

Because mercury is so much heavier than water.

If I could take all the air out of the tube, and stop the upper end, and put the other end into the tube, would the water rise in the tube if I did not touch it?

It would.

What would make it rise?

The air.

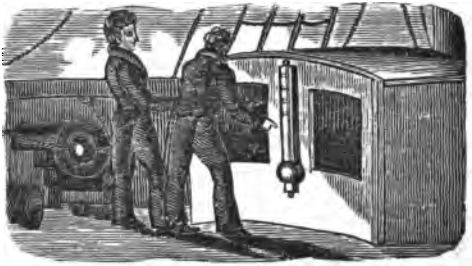
How could the air make the water rise in the tube?

By pressing down upon the water in the bowl.

What does this prove?

It proves that the air has weight.

What is the name of the instrument made of such a tube and bowl of mercury?



Barometer.

What is the meaning of the word barometer?

It means a *measurer of air.*

When the air is so heavy as to press up the mercury high into the tube, what weather do we have?

Clear, pleasant weather.

Why is the weather pleasant then?

Because the air is heavy enough to hold up the clouds, and prevent them from falling down.

How can you tell when the air grows lighter?

The mercury sinks in the tube.

What makes it sink?

The air does not press so heavily upon the mercury in the bowl, and so the mercury cannot rise as high in the tube.

What weather do we have when the mercury sinks in the tube?

Stormy weather.

Why do we have stormy weather?

Because the air is not heavy enough to hold up the clouds, and so they fall down in rain.

Then what good does a barometer do us?

It shows us what weather to expect.

Who always need barometers?

Captains of ships.

Why do they need them?

Because a sudden storm would destroy a ship sooner than it would a house.

How would a barometer prevent a ship from being destroyed?

The captain would see the mercury sinking

in the tube, and would immediately prepare the ship for the storm and thus save it.

Can you relate a story of a captain's saving his ship because he had a barometer?

Dr. Arnot gives the account. He was in the ship at the time. He says they were in the southern hemisphere. The sun had just mildly set, closing a beautiful afternoon. The evening amusements were going on as usual, when suddenly the captain's orders came, to prepare with all haste for a storm. The mercury in the barometer had begun to fall with awful rapidity. As yet, the oldest sailors could see nothing like a storm in the sky, and were surprised at the greatness and hurry of the preparations. But before every thing was quite ready, a hurricane came on them, more dreadful than the oldest of the sailors had ever known. Nothing could resist its power. The sails were torn to tatters, the masts injured, and at one time, the whole rigging was near being destroyed. So loudly, for a few hours,

did the hurricane roar above, the waves around, and the dreadful thunder peal, that no human voice could be heard ; even the speaking trumpet sounded in vain.

On that awful night, if it had not been for the little tube of mercury which gave the warning, neither the strength of the noble ship, nor the skill and activity of her commander could have saved one man to tell the tale.

LESSON TWENTIETH.

How high above the earth does the air extend?

Forty-five miles.

Then how many miles of air press down upon the mercury in the bowl?

Forty-five miles of air.

If the tube was as large as a pump, and the bowl as large as a cistern, would the water rise in the tube?

It would.

What would make it rise?

The weight of the air pressing upon the water around it.

Then what is a pump?

A large *tube* with the upper end closed.

If there was any *air* in the pump, would the water rise in it?

It would not.

Why would it not?

Because the air and water could not be in the same place at the same time, and the air would have no place to go out.

If the top of the pump was taken off, would the water rise in it then?

It would not.

Why would it not?

Because the air above the tube could then press down through the tube, and keep the water from rising.

How could the air be taken out of the pump?

By making a stopper just as large as the hole through the pump, that can slide up and down in it.

How could this drive out the air in the pur

If I should press it down to the water and then draw it up, there would be no air below the stopper.

Why would there be none?

Because the stopper is just as large as the hole and the air could not get below it.

What would be below it?

Nothing but water.

What would the water do?

It would rise as fast as the stopper rose.

What would make the water rise?

The air that pressed upon the water in the cistern outside of the pump.

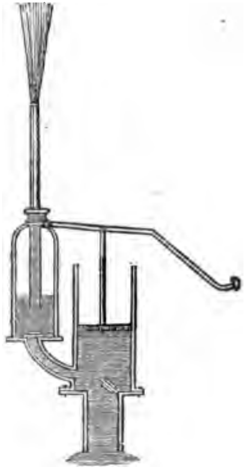
How could you raise as much water as you wish?

By pressing the stopper up and down several times.

How could the water get out of the pump, after it was raised up?

By having a spout on one side of the pump.

Here is a picture of a pump.



What is the stopper in a pump called?

It is called a piston.

How high will the water rise in a tube where there is no air?

Thirty-four feet.

Why will it rise no higher?

Because the air does not press heavily enough

upon the water in the cistern, to raise the water any higher in the pump.

What does this prove?

It proves that thirty-four feet of water weighs just as much as forty-two miles of air does.

Then which is heaviest, air or water?

Water.

Would the mercury rise thirty-four feet in a tube?

It would not.

What does that prove?

That mercury is heavier than water.

If the piston in the pump had a hole through it, what would happen when you press it down into the water?

The water would rise up through the hole.

How could you press down the piston?

By having a long pole fastened to the piston, with a handle at the top of it.

When the water has come up through the

hole in the piston, how can it be kept from running back into the cistern again?

By fastening a little leather cap over the piston, that would be lifted up.

How could the cap be lifted up, when the piston is down in the pump?

When I push down the piston into the water, the water would press up and lift up the cap, and come through.

Then when you draw up the piston what will become of the water?

The water that has come through the hole in the piston will shut down the cap, and I could draw it up.

What is this cap called?

It is called a *valve* or little door.

LESSON TWENTY-FIRST.

How do boys make the playthings which they call *suckers?*

They take a round piece of wet leather and fasten a string in the centre of it.

How do they use it?

They press the leather very closely to the stone which they wish to lift, and then when they lift up the leather with the string, the stone comes up with it.

What makes the stone rise too?

When the string pulls up the leather, it stretches the leather because it is wet, so that nothing but its edges touch the stone.

Then what is between the leather and the stone?

Nothing, not even air.

How do you know there is no air under the leather?

Because the edges of the leather are fixed so tightly to the stone, that no air could get under it.

Then what keeps the stone and leather so tightly together?

The air pressing upon the leather and upon the stone.

What does this prove?

That air has weight.

What if the edge should be lifted up on one side?

The air would get between the leather and the stone.

Could you lift the stone with the sucker then?

I could not.

Why could you not?

Because the air under the sucker would press it up, while the air above was pressing down.

Then when you wish to raise anything with a sucker, may you have any air between the sucker and the weight?

I must not.

How can a fly walk upon a window glass?

Its feet are much like suckers, and are kept upon the glass by the pressure of the air.

How can they take them up from the glass so as to walk as fast as they do?

God has given them the power of letting the air under their feet very quickly, whenever they wish to stop.

Are there any other animals that walk over smooth surfaces by means of such feet?

The lizzard that lives in the island of Java, walks up a smooth wall in the same way, to catch flies; and the large walrus walks upon ice easily, because his hind feet are shaped like a sucker.

Can you mention one more example?

There is a fish in the ocean, called *Remora*, which fixes itself upon the side of a ship, or upon a large fish, and thus travels from one part of the ocean to the other without the trouble of swimming.

How does it fasten itself upon the ship or fish?

It has a kind of sucker upon its head, which it fixes to the ship, and the water presses it close to the ship-side.

If you should cork an empty bottle, and let it down deep into the sea, what would happen to the bottle?

It would be crushed.

What would crush it?

The water pressing all around it would crush it in.

What does this prove?

It proves that the pressure of water is greater than the pressure of the air.

If you fill the bottle with water and cork it

and then let it down into the sea, will it be crushed?

It will not.

Why will it not?

Because the water in the bottle presses outward, as much as the water around the bottle presses it inward.

If you should take a tight barrel filled with water, and make a hole on one side for the water to run out, would it flow?

It would not.

Why would it not?

Because there would be nothing to press it down.

How could you make the water run?

By making a hole in the top of the barrel.

What good would that do?

It would make a place for the air above the barrel, to press down upon the water in the barrel?

Then when you wish to have the fluid in the

barrel run out at one end, what must you always do?

I must take out the *bung*, to let the air come into the barrel.

LESSON TWENTY-SECOND.

If you throw a stone into water what will the water do?

It will move in little waves shaped like circles, and these circles will grow larger and larger.

When the steeple clock strikes, what does it cause the air to do?

It makes the air move around it in circular waves, just as the water does when a stone is thrown into it.

When one of the circles reaches your ear what do you say?

I say that I hear the clock striking.

Then what is sound?

Sound is air coming against the ear.

What are these circular motions, or waves of the air called?

They are called *vibrations* of the air.

What two things are necessary then, to make a sound?

Air and the ear.

How is it known that air is necessary to make a sound?

A bell has been rung in a glass vessel, when the air was taken out of it and it made no sound.

If a cannon should be fixed several miles off, would you hear it the moment it was fired?

I should not.

Why would you not?

Because it takes sometime for the waves made by the cannon to reach my ears.

What brings the sound of the cannon to your ears?

The air.

Then what may we call the air?

A conductor of sound.

Why do we hear a bell ring more distinctly, when the wind blows towards us from the bell?

Because it brings more waves of air to our ears, than would reach us, if the wind did not blow that way.

When the wind blows in a different direction, how does the bell sound?

Very faint, and sometimes we cannot hear it at all.

Why is the sound so faint?

Because the wind blows almost all the waves of air away from our ears.

If you strike two stones together in water, can you hear the sound as plainly as you can in the air?

I can.

What does this prove?

It proves that water is a good conductor of sound.

Which is the best conductor of sound, water or air?

Water.

How can it be proved?

If a bell should be rung in water by one person, and another person at a distance, should put his head under the water, it would sound much louder than if the bell and the person were out of the water.

If you lay your ear upon one end of the table, and I scratch the other end of the table with a pin, will you hear it?

Yes, and it will sound very loud.

What does this prove?

It proves that wood is a good conductor of sound.

Why do animals seem to know an earthquake is going to take place, sooner than men do?

Their heads are so near the ground that they hear the rumbling sound first.

What does this prove?

It proves that the earth is a good conductor of sound.

Can you repeat a story that shows what good it has done, to know that the earth was a good conductor of sound?

Several years ago, there was a war in Greece. The Greeks fought against the Turks, because the Turks had got their lands away from them, and treated them very cruelly. In one of the Greek cities, there was a strong tower. The name of the city was Missolonghi. A great many Greeks had fled to this tower to get away from the Turks. The Turks came and tried to destroy the tower. It had a great quantity of powder in the cellar, for the Greek soldiers to use. After trying to destroy it a good while, the Turks went away as if they were not going to try any more. They began to dig a hole at some distance from the tower.

The Greeks did not know what it was for; but soon one Greek began to think that the Turks were digging a hole under ground to reach to the cellar of the tower. He thought that they would lay tow all along, from the powder in the cellar to the beginning of the hole, and then set fire to the tow. This would burn till the fire got to the powder in the cellar, and then that would take fire and blow up the tower and all the people in it.

What did the Greek do?

He piled up some stones in the middle of the cellar, or magazine, and put four smaller stones very loosely upon the tip. Then he watched these four stones till he saw them shake. As soon as they began to shake, he put his ear down to the earth, and could hear which way the sound came from. As soon as he found out which way it came from, he began to dig down, and soon came to the tow that was laid there, all ready to be set on fire. This he destroyed. When the Turks had set the farther

end on fire, they waited at a distance to see the tower blow up. When they found that it did not blow up, they began to dig somewhere else.

What did the Greek do then?

He kept watching the stones, and soon saw them shake again. Then he put his ear down and heard the noise, and dug again till he came to another train of tow, and destroyed that.

Did the Turks try again?

They did several times, but after some time they began to think that the Greeks knew what they were doing, and so they gave over trying to blow up the tower.

LESSON TWENTY-THIRD.

How fast does sound pass through the air?

About a mile in six seconds of time.

Then if you should see the flash of a cannon, and could count thirty seconds before you hear the first sound, how far off should you say the cannon was?

It would be *five* miles off.

How could you tell?

If it goes one mile in six seconds, it would go five miles in thirty seconds, because there are five times six in thirty.

If it should lighten, and you should not hear it thunder till you had counted eighteen seconds,

how far off should you say the thunder cloud was?

Three miles off.

How would you find out that?

There are three times six seconds in eighteen seconds, and if six seconds would bring the sound one mile, eighteen seconds would bring the sound three times as far, which would make three miles.

If you speak very low, what will the air around you do?

It will begin to move or *vibrate* in circles, that will spread farther and farther.

If these circles spread till they strike against a high rock, what will happen to them?

The rock will *reflect* or send them back, just as it would a ball, if you threw one against it.

If the circles made by the reflection of the rock should come back to your ear, what would you say?

I should say I hear the *echo* of my voice.

Then what is an *echo?*

An echo is sound sent back again.

What will send back sound?

Rocks, walls, and mountains, if they are near enough and not too near.

How near must they be, in order to make an echo when you speak very loud?

So near that the circles made by my voice can reach them, and that they can send the circles back to me.

If the rock should send its circles to another rock that would send them back to your ear, what would you hear?

I should hear *two* echoes.

How would it be if a great many rocks should do the same?

I should hear several echoes.

Are there any places where several echoes can be heard?

There are many in the world.

Can you mention one in the United States?

At Lake George there is a place where a

person can stand and call out very loudly, and he will hear several echoes.

What curious echo is there in England?

At Woodstock, there is an echo that will repeat seventeen syllables; and on the north side of the church at Sussex, the echo will repeat twenty-one syllables.

What one still more wonderful can you mention?

In Italy, near the city of Milan, there are two walls of a building that face each other, and a person standing at a window between them, can hear the echo repeat one word more than *forty* times.

How is it when a pistol is fired there?

The echo repeats the sound *sixty* times.

What can you say of the Whispering Gallery of St. Paul's Church in London?

If a person whispers very softly close to the wall on one side of the gallery, it will be echoed so that if another person puts his ear close to

the wall on the other side of the gallery, he can hear every word distinctly.

What is an Eolian harp?

A musical instrument made with strings.

Can you describe it?

Strings or wires are stretched very tightly from one fastening to another, and placed where the wind can blow upon them.

What does the wind do to the strings?

It makes them strike against the air, and when the circles made by them reach your ears, you hear very sweet sounds.

What very large one was made in Milan many years ago?

Gattoni stretched seven strong iron wires from the top of a tower fifty feet high to the house of Signor Mascati.

What was it called?

The *Giant's Harp*.

Why was it called the Giant's Harp?

Because when the wind blew, it sent forth

such lengthened peals of music; now it was a loud chorus, and then it died away in soft murmurings. In a storm it was heard several miles.

LESSON TWENTY-FOURTH.

INTO how many colors may light be separated?

Light may be separated into seven colors.

What are the names of these colors?

Violet, indigo, blue, green, yellow, orange, red.

When light shines upon a sheet of paper, how can you see the paper?

By the light which the paper *reflects* or *throws back* to my eyes.

Would the paper reflect *all* the light that shines upon it?

If it was *white* paper, it would.

How do you know that *white* paper reflects *all* the light that falls upon it?

Because it takes all the seven colors to make *white* light, and the paper looks white, which it could not do, if it did not reflect *all* the seven colors.

How do you know that it takes all the seven colors to make white?

Because if you separate a ray of light by a prism, it will be changed into just seven colors, and no more, and if you bring all these seven colors together again, they will be changed to a ray of white light.

Do all bodies reflect all these colors?

They do not; some reflect one color, and some another.

What becomes of those colors which the body does not reflect?

That body *absorbs* them.

What do you mean by a body's *absorbing* colors?

It seems to take them into itself, so that we cannot see them.

If a body should absorb all the colors and reflect none, what color would it have?

It would not have any color.

Then what should we call it?

We should call it a *black* body.

Then is black a real *color?*

It is not.

Then when we say a body is *black*, what do we mean?

We mean that the body has *no* color.

And when we say a body is *white*, what do we mean?

That it has *all* the seven colors.

If it absorbs all the colors but the red, and reflects the *red*, of what color will the body be?

It will be a *red* body.

What color shall we call it, if it reflects the green, and absorbs all the rest?

We shall call it a *green* body.

How can you tell which color a body reflects and which it absorbs?

It will be of the color it reflects, and we shall know it absorbs all the other colors but that.

Then how do we see any object?

By the color it reflects to our eyes.

What is the reflection of light like?

Like the reflection of sound.

Can you explain it?

The sun shines upon a green leaf, and the leaf reflects the green color to my eyes, just as a person stands out of my sight and calls, and the rock on which the sound of his voice falls, reflects it to my ear.

Why do not all bodies reflect *the same* color and absorb the others?

Because the particles of bodies are put together differently, so that one body can reflect one color, another all of them, and another none.

Which would reflect *all?*

A *white* body.

Which would reflect *none?*

A *black* body.

If you should go into a perfectly dark room, and let in a ray of light through a small hole, and put a *prism* over this hole, what would the prism do to the light that came through it?

It would separate it into the seven colors.

Would all these colors be mixed together?

They would not.

How would they be?

They would lie one beneath the other very distinctly, like the rainbow.

Then do they all go through the prism in a straight line together?

They do not; they are broken and turned out of the straight line.

When a ray of light is broken and turned out of a straight line in passing through a body, what do we say of it?

We say the light is *refracted.*

What is the meaning of *refract?*

To *break*.

When is light *refracted?*

When it is *broken*.

If you should put a piece of white paper into the *blue* ray that has passed through your prism, of what color would the paper be?

It would be *blue*.

Why would it be blue?

Because it could reflect only the blue color.

Why would it not be white?

Because it must reflect the seven colors to make white, and there is but one for it to reflect, when the blue alone falls upon it.

If you should put the paper into the yellow ray, of what color would it be?

It would be yellow.

What does this prove?

It proves that bodies are of the color which they *reflect*.

Then if no light should fall on a body, would it have any color?

It would not.

Why would it not?

Because there would be no color for it to reflect.

When a body does not reflect any color, what do we call it?

A *black* body.

If a room is so dark that no light can enter it, of what color will the objects in the room be?

They will be of *no* color, because there is no color to be reflected.

Then what must we call them, as long as they are in the dark?

We must call them *black* bodies.

Can we ever see them when they are made black in this way?

We cannot; because we can see nothing when it is *perfectly* dark.

Why can we see a tree upon the top of a hill at a distance, plainer than we can see one on a plain or in a valley at the same distance?

Because the sky behind the tree on the hill

is so much lighter than the tree, that we can see the shape of the tree very distinctly.

Why is not the tree in the valley as distinct as the one on the hill?

Because the green color of the grass behind the tree seems to mingle with the green of the tree, and we cannot distinguish the one from the other.

Why can we see a *white* house at a distance, plainer than we can see a tree at the same distance?

Because there is so great a difference between a white object and a dark one.

If you wish to make a room very light, what should you do, besides having many windows in it?

I would have it painted white, and the walls should be white or papered with very light colored paper.

Why would light paint and paper make a room lighter than dark paint and paper, if there was the same number of windows in it?

Because white walls throw all the light that falls upon them back into the room, and dark walls absorb a part of the light, and reflect only a part into the room.

Why do people who have weak eyes, wear a green shade over them in the day time, when reading?

To keep the light that is reflected from the walls of the room from coming into their eyes.

Why do they wear them when reading by candle light?

To prevent the rays of light that come from the candle, from entering their eyes.

Is *heat* reflected in the same manner that light is?

It is.

Then why is a white dress so cool in summer?

Because it reflects the heat of the sun.

Why is a black dress so warm?

Because it absorbs all the heat, and reflects none.

When the heat of the sun falls upon the

side of a mountain white with snow, what becomes of this heat?

It is reflected in every direction.

If a valley is surrounded with such mountains, will it be warm or cold?

It will be warm.

Are there any such valleys?

There are valleys in Switzerland surrounded by such mountains, that receive so much reflected heat from every side, that they are always green, though they are in the midst of perpetual snow.

LESSON TWENTY-FIFTH.

How high from the earth does the atmosphere extend?

About forty-five miles.

From what does all our light come?

It comes from the sun.

When the rays of light, in coming from the sun, enter the atmosphere, what happens to them?

They are refracted, or broken and turned out of their course.

What refracts them?

The atmosphere.

Does it also separate the light into different colors, like the prism?

It does not; it only breaks them.

If the atmosphere becomes more *dense* or *thick*, how would the light be refracted?

It would be refracted more and more, the more dense the atmosphere becomes.

When light passes through a prism, which colored ray is refracted the most, or turned the farthest out of its course?

The violet.

Which is refracted the least?

The red.

What is it that refracts the light?

The glass of which the prism is made.

If light passes through water, is it refracted more or less than when it passes through the atmosphere?

It is refracted more.

If a stick is put into water so that one part of it is in the water and the other part

out, how will the light be reflected from each part?

It will seem to come straight to your eye from the upper part of the stick, and the stick will appear broken where it goes into the water.

What will make it seem broken?

The rays of light from the lower part of the stick are turned so much out of their course by the water, that when they enter the air they turn partly back again, and come with the others to your eye, and thus the stick appears bent or broken, because the rays of light that come from it, are really bent.

Why does water refract light more than the atmosphere?

Because it is more dense than air.

Then what bodies refract light most?

The densest bodies through which light can pass refract it most.

Why does the sky or atmosphere look blue?

The rays of light come from the sun, pass

through the atmosphere to the earth, and are reflected back through the atmosphere, and the *blue* rays are stopped on their way and reflected again to our eyes.

What becomes of the other colors?

They pass on through, without being reflected.

Why are the blue rays stopped?

Because they do not seem to have momentum enough to carry them through.

What did you say was the meaning of *momentum?*

The power and velocity of a body put together.

Then what do you mean by the momentum of a blue ray?

Its power to carry itself through the atmosphere.

Which color has the greatest momentum?

The red.

If the atmosphere should become very thick

or dense, what would be the effect upon the light that passes through it?

None of the rays but the *red* would have momentum enough to pass through the atmosphere.

When does the sun look red?

When it is seen through a fog or vapor.

If the atmosphere did not reflect any of the sun's rays, how would the sky appear?

Perfectly black.

When bodies do not allow any light to pass through them, what do we call such bodies?

Opaque bodies.

Can you mention an opaque body?

A piece of wood, or marble, or iron, is opaque.

How can you tell?

By holding them up to see whether the light will pass through them.

When a body permits light to shine through it, what kind of a body is it called?

A *transparent* body.

Will you mention some transparent body?

Glass is transparent.

Why is it transparent?

Because light can pass through it.

Is water transparent?

It is.

Then why is it more difficult to see bodies distinctly through a fog, than when the air is clear?

The fog refracts these rays of light that bodies reflect through it, so much more than air does, that we cannot distinguish the size and shape of those bodies very well; they seem much larger than they really are.

Can you relate a story about a singular mistake, caused by a dense fog or mist?

A shepherd upon one of the Cumberland mountains, in Europe, was suddenly surrounded with a thick fog. Every thing seemed so very large that he lost his way. He tried to find some object that he knew, and by which he could find where he was, and where he ought

to go. He soon came to what seemed to be a very large mansion, which he did not remember of having seen before. He went into it, to inquire the way home, and there found his own family. It was his own cottage. The fog had deceived him so much, that it was some time before he could believe the fact.

Do clouds ever reflect shadows of objects that are before them?

They do.

Will you mention one instance?

Forty years ago, a Mr. Hane went up the Hartz mountains in Germany, at a place called the Broken. As he looked towards the southwest he saw, at a very great distance, the figure of a man, as large as a giant. Just then a gust of wind almost blew off his hat, and he raised his hand to his head to keep on his hat. The figure did the same. He then bent his body, as if to salute it. The figure returned it at the same instant. He then went back and took another man with him. They t'

saw two such giant figures; and all that these men did, the figures imitated.

What was the cause of this appearance?

When the sun is rising or setting, and throws his rays over the Broken, upon the fine light clouds floating around, if a man comes between the rays of light and the cloud, the shadow of the man will be seen on the clouds opposite him, and all his motions will be represented by his shadow.

How large will his shadow be?

It will extend *five or six hundred feet.*

How far from the man will it be?

Two miles off.

What name have the ignorant people in that country given to this immense shadow?

They call it the *Spectre of the Broken.*

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